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Return-On-Investment Study for Rehabilitation of Military Training Areas Damaged by Tracked Vehicles

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At Fort Carson, CO, the impact of long-term, intense military training on vegetation and topography is becoming increasingly evident. After more than 20 years of intensive training, vegetation is so reduced that it adversely impacts the quality of military training. In addition, large gullies have developed in some locations, making navigation by tracked vehicles difficult, if not impossible. Unless training use and proper land management are brought into balance, similar results can be expected to develop at the Pinon Canyon Maneuver Site (PCMS) as training expands in that area. This report presents a return-on-investment (ROI) study of the benefits that should result from implementing a long-term vegetation management program at Fort Carson and PCMS.

Results of this study show that rehabilitation and maintenance are cost-effective for the Army. Estimates of the Government's savings at Fort Carson and PCMS vary from over $299 million to more than $1.65 billion. Depending on assumptions about the replacement value of site facilities used, the ROI (ratio of cost savings to expenses) for implementing a rehabilitation program varies from a low of 5, if original facility and land costs are held constant, to a high of more than 27, if current replacement costs are considered.

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At Fort Carson, CO, the impact of long-term, intense military training on vegetation and topography is becoming increasingly evident. After more than 20 years of intense training, vegetation is so reduced that it adversely impacts the quality of military training. In addition, large gullies have developed in some locations, making navigation by tracked vehicles difficult, if not impossible. Unless training use and proper land management are brought into balance, similar results can be expected to develop at the Pinon Canyon Maneuver Site (PCMS) as training expands in that area. This report presents a return-on-investment (ROI) study of the benefits that should result from implementing a long-term vegetation management program at Fort Carson and PCMS. Study results

Results of this study show that rehabilitation and maintenance are cost-effective for the Army. Estimates of the Government's savings at Fort Carson and PCMS vary from over $299 million to more than $1.65 billion. Depending on assumptions about the replacement value of site facilities used, the ROI (ratio of cost savings to expenses) for implementing a rehabilitation program varies from a low of 5, if original facility and land costs are held constant, to a high of more than 27, if current replacement costs are considered.

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FOREWORD

This investigation was performed for the U.S. Army Engineering and Housing Support Center (USAEHSC) in coordination with the Headquarters, U.S. Army Corps of Engineers (HQUSACE) Directorate of Research and Development (DRD), under the Facilities Engineering Applications Program (FEAP). The project area for this FEAP work was "Environmental Quality." The work was performed under contract to the Environmental Division (EN) of the U.S. Army Construction Engineering Research Laboratory (USACERL). The Technical Monitor was Mr. Donald Bandel, CEHSC-FN.

The return on investment was primarily prepared by ESCOR, Inc., Northfield, IL, under contract to the Renewable Resources Section, Energy and Environmental Systems Division, Argonne National Laboratory (ANL). ANL was the prime USACERL contractor for the rehabilitation aspects of the study. R. Eric Zimmerman is with ESCOR, Inc. Donald O. Johnson, Raymond R. Hinchman, and Ralph P. Carter are ANL researchers. The assistance and constructive comments provided by Mr. Thomas Warren, Environmental Officer, Directorate of Engineering and Housing, Fort Carson, CO, and his staff are gratefully acknowledged. Dr. Steven Warren, USACERL, also provided many constructive comments. Dr. Edward W. Novak is the Team Leader of the Environmental Resources Team, USACERL-EN. Dr. R. K. Jain is Chief of USACERL-EN. The USACERL technical editor was Gloria J. Wienke, Information Management Office.

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RETURN-ON-INVESTMENT STUDY FOR REHABILITATION OF MILITARY TRAINING AREAS DAMAGED BY TRACKED VEHICLES

1 INTRODUCTION

Background

Fort Carson, CO, is the training site for the 4th Infantry Division (Mechanized) (4th ID[M]), several support units, and a number of National Guard and Army Reserve units. It was established in 1942 at 60,000 acres. Expanded to 137,371 acres in 1965 because an increase in the level of training required larger maneuver areas, it now totals 137,391 acres, of which 56,710 acres can be used for tactical maneuvers.[1]

A need for even more training area became apparent in the early 1970s. In 1974, Omaha District of the U.S. Army Corps of Engineers (USACE) estimated the average cost of expanding training to areas contiguous to Fort Carson would be $859 per acre. An extensive study to find parcels of land on the order of 200,000 acres or more within an acceptable travel distance from Fort Carson was undertaken. This eventually led to the acquisition of the Pinon Canyon Maneuver Site (PCMS), 235,995 acres, located approximately 150 miles southeast of Fort Carson.[2]

Fort Carson and PCMS are, in effect, used as one training ground. Fort Carson contains housing, support, and maintenance facilities, as well as an airfield, artillery range, and tracked vehicle maneuvering area. PCMS contains tracked vehicle maneuvering areas and recently constructed support facilities.

Two major plant communities exist on each site. Short-grass prairie occurs primarily on even, sloping eastern areas; woodlands include both pine-juniper and ponderosa pine-oak areas and occupy the steeper western foothills at Fort Carson and the canyons and foothills of PCMS. Woodlands are favored for concealment training and maneuvering of tracked vehicles because they provide desirable viewing and firing positions as well as tactical concealment. However, they are also the areas most sensitive to disturbance from training activities.[3] The prairies are also extensively used for maneuvering.

The impact of long-term, intense military training is becoming increasingly evident. After more than 20 years of intensive training at Fort Carson, vegetation is so reduced that it adversely impacts the quality of military training. In addition, large

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[1] *Inventory of Army Military Real Property, the United States* (Department of the Army, Office of Chief of Engineers, 30 September 1985); *Draft Environmental Impact Statement (EIS), Training Land Acquisition for Fort Carson, Colorado* (Department of the Army, Headquarters, Fort Carson and 4th Infantry Division [Mechanized], 1980).

[2] *Draft Environmental Impact Statement, Training Land Acquisition for Fort Carson, Colorado.*

[3] R. Hinchman, K. McMullen, R. P. Carter, and W. D. Severinghaus, *Rehabilitation of Military Training Areas Damaged by Tracked Vehicles at Fort Carson, Colorado*, USACERL Technical Report N-90/15 (August 1990).

gullies have developed in some locations, hindering navigation by tracked vehicles. Unless training use and proper land management are brought into balance, similar results can be expected to develop at PCMS.

As both sites receive additional training pressure, increased erosion and tree destruction will greatly reduce their value for future training or any other purpose. The options available to the 4th ID(M) are (1) develop a long-term training area management program that will allow repeated use while preserving site features, (2) continue to use the sites without intense land management but at a loss of training realism as they become severely damaged, or (3) alter the mission and/or abandon the sites when they become unacceptable for military training.

In 1983, USACERL began a rehabilitation and maintenance demonstration project (Integrated Training Area Management/ITAM)* at Fort Carson as part of the Facilities Engineer Application Program (FEAP).** The objective of the demonstrations was to show that stabilization and restoration of severely disturbed lands can be accomplished effectively.

Objective

This report documents a return-on-investment (ROI) study conducted to quantify the relative value of recent rehabilitation strategies being demonstrated at Fort Carson. The objective of the ROI study is to show that long-term land management and rehabilitation activities are cost-effective and support mission requirements.

Approach

The ROI calculations for this study were conducted by ESCOR, Inc., a private firm in Northfield, IL. The rehabilitation demonstration effort described was conducted by Argonne National Laboratory (ANL) for the U.S. Army Construction Engineering Research Laboratory (USACERL) as part of the FEAP. ANL and USACERL provided the information for the ROI calculations.

In this study ROI is defined as the cost avoidance (or savings) divided by cost and is a benefit/cost calculation. A major assumption is that if proper long-term land management is not practiced, at some future date Fort Carson will have little value as a tactical maneuver area, and a new training area will have to be obtained.

ROI values are not absolute because many benefits resulting from land management efforts are subjective; for example, determining the value of better military training. Although it is possible to quantify the costs of a tank and the crew's training ($1.7 to $1.8 million), it is almost impossible to determine the value of the crew's lives and the value of an optimally functioning armored vehicle in combat. Thus, the only quantifiable costs included in the analysis are those of rehabilitation, land, and facilities at the sites.

The ROI analysis was conducted both for the FEAP demonstration itself and for establishment of a long-term land management/rehabilitation program. ROI for the demonstration was accomplished to show its value in fostering new technologies and/or technologies applicable to problems unique to the Army. The ROI for establishment of a

*This was the first Integrated Training Area Management (ITAM) project.
**Formerly called the Facilities Technology Test (FTAT) program.

long-term rehabilitation program was accomplished to show the relative benefit of land maintenance not only at Fort Carson and PCMS but at most installations where tactical maneuver training occurs.

ROI analysis was conducted for five different cases. In each, cost variables were changed to accommodate a range of unknowns in the value of facilities replacement at Fort Carson. In addition, sensitivity analysis was conducted on a number of variables used in the ROI calculations to examine the impact certain assumptions might have had on the outcome of the ROI.

Mode of Technology Transfer

The ROI itself is not applicable to any formal technology transfer. Rather, it is documentation of the value of establishing a long-range land management program. As a result, reporting of this data beyond the present report is not foreseen.

Based on efforts initiated under the FEAP program at Fort Carson and PCMS and through reimbursable efforts at other installations, USACERL has developed an overall training area management concept called the Integrated Training Area Management (ITAM) program. Technology transfer of the elements of this program, including land inventory and monitoring, training integration, educational awareness, and technologies for land management, scheduling, rehabilitation, and maintenance, will be forthcoming through a variety of mechanisms. Among these will be workshops, videotapes, technical reports, engineering technical notes, systems releases, and, ultimately, technical manuals on program implementation.

Efforts to continue to address the economic efficiencies of ITAM in a manner similar to this ROI will also be made. These will be reported to the field in technical reports, society presentations, articles, and engineering technical notes.

2 REHABILITATION RESEARCH

Site Descriptions

Fort Carson is located in south-central Colorado in the transitional zone where the Great Plains merge with the foothills of the eastern front of the Rocky Mountains. The site varies in elevation (mean sea level) from 5100 ft in the southwest corner to 6960 ft at the northwest boundary. Yearly precipitation varies from 11 in. in the southeast to 16 in. in the northwest. Rainfall is low and erratic when compared to areas east of the Mississippi River and may fluctuate from one-half to two times the average amount. Vegetation varies from short-grass prairie with deep, silty clay soils in the eastern areas to thin-soil woodlands in the steeper western foothills. Both predominant tree species, pinyon pine and juniper, are slow-growing species requiring 50 to 100 years for maturity. Grasses and some shrubs can be regrown over several growing seasons.

The steeper foothills are the most desirable areas for military training but are also the most sensitive to military use. Intensive training activities have destroyed grasses, shrubs, tree seedlings, and mature trees and have resulted in erosion gullies and myriad barren, rutted tank trails. Vegetative cover on tank trails and numerous large tracts of land has been reduced to less than 10 percent. A number of these areas cannot be freely used during periods of moderate-to-high winds because of blowing dust. In addition, a loss of training realism results from the reduction of vegetative cover. Large gullies present in a few areas make training almost impossible. Also, because tank trails are visible, troops lose the opportunity to develop decisionmaking skills by determining where to drive their vehicles.[4]

PCMS is located at the juncture of the Colorado-Piedmont and Raton sections of the Great Plains Physiographic Province. The 235,995-acre site varies in elevation from over 5700 ft at the northwest boundary to less than 4300 ft where the Purgatoire River exits the site. The higher elevations are generally piedmont or more moderate types of topographic features; the extreme topography is located in deep canyons with well-developed cliffs along the rivers. In general, precipitation at PCMS is less than at Fort Carson. PCMS soils are similar to those at Fort Carson, but are more susceptible to wind erosion, and major plant communities are also similar.[5]

Since training activities have begun only relatively recently, major damage to PCMS has not yet occurred. However, because of the site's lower rainfall and great susceptibility to wind erosion, impacts can be expected to accelerate as use of the site increases.

Existing Programs

Three land rehabilitation programs were operating at Fort Carson during the FEAP project. One program included management of gully erosion; another scheduling rest periods for selected training areas; and the third, selective land maintenance practices, particularly pitting and seeding, as funds become available. The latter is a continuous effort by the Fort Carson staff and is not a part of this ROI analysis; the other two programs are. The first was conducted through the USACE FEAP program, and the other

[4] R. Hinchman et al.
[5] *Draft EIS, Training Land Acquisition for Fort Carson, Colorado.*

was conducted for the Fort Carson Environmental Office by the U.S. Soil Conservation Service (SCS). The two programs were complementary in that the FEAP effort focused on the pinyon pine and juniper foothills, with their very thin soil conditions and adjacent grassland areas, and the SCS effort focused on the loamy plains and the adjacent foothills on the western side of the installation. The two projects overlapped, but their primary foci were the two ecological extremes, i.e., the pinyon/juniper foothills and the loamy plains.

The reclamation approaches undertaken in the two programs were different because of site-dictated conditions. On the open, loamy plains where the SCS program was located, equipment is unhindered by slope, gullies, and trees. In the pinyon/juniper foothills used for the FEAP demonstration, gullies, topography, and the necessity to work outside the drip line of existing trees make seed-bed preparation, fertilization, and general reclamation operations difficult. In fact, these areas were designated as unreclaimable in the Fort Carson Land Use and Management Plan (LUMP).[6]

For comparison and demonstration, it is most desirable to construct side-by-side plots in uniform areas. This was done in the SCS effort because topographic conditions at the site permitted it. The SCS plot was 11.5 acres, 480 ft by 1040 ft, and was divided into subplots that demonstrated various levels of disturbance and made use of differing rehabilitation techniques. The 85-acre USACERL FEAP site, with its rough terrain and steep slopes, did not lend itself to this comparative procedure. Because a series of steep ridges in the center of the site were inaccessible, the actual test area consisted of 71 acres with eight study plots. Four areas totaling approximately 40 acres, were designated as rehabilitation treatment areas, and four areas were left untreated. The level of disturbance in the study area caused from training activities ranged from severe to none.

The rehabilitation prescription developed for the FEAP site included the selection of appropriate plant species, fertilization, tillage, seedbed preparation, planting, plowing, and monitoring. In this test the seeding mixture's potential for successful survival was a more important consideration than its cost. Cost was also of secondary importance when fertilization, seedbed preparation, seeding, aerating, and other test activities were conducted. Thus, the initial effort aimed to demonstrate that (1) the proposed rehabilitation would work and (2) these areas can be successfully maintained. Later studies should examine alternative land treatments and species selection to develop a specialized rehabilitation approach and improve the long-term economics.

Although beyond the scope of this ROI study, the specific treatment processes used by the SCS and ANL efforts are described in reports by Cammack and Hinchman et al.[7] These reports also document the relative success of the rehabilitation approaches. However, the long-term success of either approach has yet to be documented. Although data on rehabilitation resilience under training pressure remains uncollected, for purposes of this ROI analysis both approaches are considered successful. It is sufficient to state that both efforts increased ground cover, thereby reducing erosion and providing much more realism for training.

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[6] *Land Use and Management Plan for Fort Carson, Colorado* (Department of the Army, Fort Carson, Dames & Moore, Denver, December 1977).

[7] Cammack, R., *Range Trend Study on Fort Carson* (Soil Conservation Service, U.S. Department of Agriculture, October 26, 1986); R. Hinchman et al.

Rehabilitation Cost Variables

The rehabilitation costs used for this ROI study are based on the cost data and projections from both the SCS and FEAP rehabilitation demonstration projects. These costs are shown in Table 1 for the FEAP site and in Table 2 for the SCS site.

The first column in Table 1 shows actual costs for the 40-acre FEAP site*, including both the pinyon pine and juniper areas and short-grass prairie area. The average cost per acre for the rehabilitation demonstration was $402. From this information, the costs that would result if different seed mixtures and reclamation-site sizes were used is projected. For example, at one 200-acre plot in the pinyon-juniper area, using the FEAP seed mixtures, estimated cost was $294 per acre. The cost for a short-grass prairie site of similar size, using a specialized reclamation seed mix, would be $194 per acre. Using the SCS seed mix would reduce the cost to $199 and $159 per acre, respectively. Increasing the size of the plots from 200 to 1000 acre plots would result in costs of $264 and $167 per acre, respectively. Using the SCS mix would reduce the costs at these 1000-acre plots to $177 and $137 per acre, respectively.[8]

Table 2 shows the projected SCS reclamation costs for 200-acre sites at both the loamy plains and the loamy foothills sites. The SCS treatment alternatives varied from doing nothing to complete seed bed preparation, and they cost from $0 to $289 per acre.[9]

The relative success of either of the two approaches at the overlapping areas is difficult to estimate, especially since the long-term success of either approach has yet to be documented.

[8]R. Hinchman et al.

[9]R. Cammack.

*Forty acres was the test portion; the other 44 acres served as the control.

Table 1

Fort Carson Rehabilitation Cost Data ($/acre)

	FEAP Site	Pinyon-Juniper Sites		Short-Grass Prairie Sites	
Cost Item	**40 acres**	**200 acres**	**1000 acres**	**200 acres**	**1000 acres**
Operations					
Fertilization	40				
Tillage	55				
Seeding	60				
Harrowing	20				
Subtotal	**175**	**140**	**130**	**125**	**115**
Type of seed mixture[a]	FEAP	FEAP SCS	FEAP SCS	SRM SCS	SRM SCS
Mulch[b]					
Seed	182	145 50	132 45	60 25	50 20
Mobilization	45	9 9	1.80 1.80	9 9	1.80 1.80
Average total cost per acre	402	294 199	264 177	194 159	167 137

[a] The FEAP seed mixture was developed by Argonne National Laboratory (ANL); the SCS seed mixture was developed by the U. S. Soil Conservation Service; SRM represents the ANL projected cost of a specialized reclamation mixture which would be suitable for shortgrass prairie sites using the FEAP reclamation technologies.

[b] Not applicable; no mulch was used by ANL. This item is included for comparison with SCS operations shown in Table 2.

Source: R. Hinchman et al.

Table 2

Soil Conservation Service Reclamation Costs for Eight Treatment Alternatives at 200-Acre Sites ($/acre)

Cost Item	Loamy Foothills Sites 1	2	3	4	5	6	7	8
Operations								
Fertilization	--	--	--	--	35.70	35.70	35.70	35.70
Tillage	--	6.50	6.50	6.50	6.50	6.50	10.50	10.50
Seeding	--	--	8.00	8.00	8.00	8.00	8.00	8.00
Harrowing	--	--	--	--	--	--	1.50	1.50
Subtotal	0	6.50	14.50	14.50	50.20	50.20	55.70	55.70
Mulch	--	--	--	--	--	--	196.00	196.00
SCS Seed	--	--	35.50	36.88	35.50	36.88	35.50	36.88
Mobilization	--	--	--	--	--	--	--	--
Average total cost per acre	0	6.50	50.00	51.38	85.70	87.08	287.20	288.58

Cost Item	Loamy Plains Range Sites 1	2	3	4	5	6	7	8
Operations								
Fertilization	--	--	--	--	35.70	35.70	35.70	35.70
Tillage	--	6.50	6.50	6.50	6.50	6.50	10.50	10.50
Seeding	--	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Harrowing	--	--	--	--	--	--	1.50	1.50
Subtotal	0	14.50	14.50	14.50	50.20	50.20	55.70	55.70
Mulch	--	--	--	--	--	--	196.00	196.00
SCS Seed	--	--	35.50	36.88	35.50	36.88	35.50	36.88
Mobilization	--	--	--	--	--	--	--	--
Average total cost per acre	0	14.50	50.00	51.38	85.70	87.08	287.20	288.58

Source: R. Cammack.

3 BASIS FOR COST

For the ROI values to be more than speculative, the costs and benefits resulting from implementing a long-term site maintenance program must have some factual basis. Specific operational alternatives, costs, and benefits are discussed below.

Operational Alternatives

Two extreme alternatives for facilities operations are addressed in this study. The first alternative is to retain the status quo, i.e., to continue operating Fort Carson and PCMS until the land has little or no further value for realistic maneuver training. The result would mean abandoning the sites as tactical training areas, obtaining a new training site, and perhaps constructing new facilities at a new site. The second alternative is to implement a long-term land maintenance program that is integrated into site operations, thus maintaining the lands and facilities for sustained use.

Other alternatives involving mission changes are also available, but the choice of mission change and the selection of alternative parameters associated with a mission change are beyond the scope of this ROI analysis. Therefore, the alternatives considered in this report are based on the two extremes. As a result, abandonment, as well as replacement of existing facilities for the 4th ID(M), is a major cost in allowing the training land to become unusable.

In defense of this approach, movement of the 4th ID(M) to another location would require additional facilities construction. No U.S. facilities can accommodate the Division except for installations with a similar mission. If the 4th ID(M) were relocated to such an installation, this would displace units currently at those locations and still result in significant requirements for new facilities. Relocation costs, i.e., transportation and facilities renovation, would also be incurred, and these costs would be significant.

A mission change with any similar-size installation having a different mission may be plausible. The 4th ID(M) could relocate to a similar-size U.S. Army Training and Doctrine Command (TRADOC) installation, and the TRADOC mission could be relocated to Fort Carson. TRADOC missions are generally less land intensive, and the life of Fort Carson could be extended without an intensive land maintenance program. However, relocation costs would be incurred, and unless intensive land maintenance were implemented at the new location of the 4th ID(M), management problems similar to those facing Fort Carson would develop, which would eventually require another relocation and further replacement costs. Another option would be to change the mission of the 4th ID(M) to reduce training requirements and intensity. However, an analysis of such an option, which might affect the overall military readiness mission, would require considerably more time and effort than is available for this study. Therefore, the two extreme alternatives remain the basis for this ROI, and facilities replacement costs are included. Where possible, these and other costs have been conservatively estimated.

Nonquantifiable Costs and Benefits

A number of nonquantifiable costs and benefits will result if the long-term land management program is implemented. As previously mentioned, however, the costs and benefits of better-trained troops, possible savings in human life, and better performing

military units cannot be quantified except for costs of $1.7 to $1.8 million per vehicle and trained crew. Thus, the benefits of better military training are not incorporated into this study. The improved ecology resulting from maintaining the sites is another benefit not included in the ROI study. Additional factors, such as a site's proximity to Colorado Springs or Denver, its uniqueness, and its historical value, are also not considered.

Facility Costs

The costs of the Fort Carson and PCMS facilities are well-documented in the 1985 *Inventory of Army Military Real Property.* The three cost categories for each site are the costs for land acquisition, buildings, and other prominent structures. These are the costs to the government at the time of purchase (not replacement costs) and are shown in Table 3.

Land Costs

The average cost of land was $46 per acre for Fort Carson and $104.40 per acre for PCMS. These costs reflect the original purchase cost and are not indicative of replacement costs, which were estimated by the U.S. Army Corps of Engineers in 1974 to be $859 per acre for an expansion of the Fort Carson site to contiguous areas.[10]

Rehabilitation Costs and Treatment Interval

The rehabilitation efforts undertaken by ANL and SCS are discussed in Chapter 2. The 1986 costs for land treatment developed from these two projects are the basis for estimating the long-term treatment cost. The FEAP program indicated that the cost for reclamation of woodlands on 1000-acre plots will vary from $177 to $264 per acre (Table 1). SCS estimates for reclaiming the loamy plains on 200-acre plots varied from $14.50 to $289 per acre (Table 2).

The actual cost of implementing these programs is expected to decrease as the techniques are refined and economies of scale are experienced. ANL personnel estimated the likely long-term per-acre maintenance costs to be $50 for prairie sites and $150 for woodland sites. For this analysis, however, baseline costs of $50 per acre for prairie sites and $175 per acre for woodland sites are assumed; woodland costs are assumed to be somewhat higher since rehabilitation in these areas can be labor and equipment intensive.

In addition to prairie and woodland sites, the topography of much of Fort Carson and PCMS includes sandstone and limestone break areas that contain some trees and sparse vegetation. Because many of these break areas are inaccessible and the vegetation is sparse, their reclamation cost is based on an average of the prairie and woodland areas. Thus, baseline costs for reclaiming the break areas are assumed to be $113 per acre. These costs are included althougn intensive rehabilitation in the break areas may not be a realistic part of a continuous maintenance program.

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[10] *Draft Environmental Impact Statement (EIS), Training Land Acquisition for Fort Carson, Colorado.*

Table 3

Purchase Costs

Item	Cost
Fort Carson	
Land	$ 6,325,400
Buildings	221,179,800
Other	116,039,500
Total	$343,544,700
Pinon Canyon	
Land	$ 24,638,000
Buildings	0
Other	4,797,900
Total	$ 29,435,900

Source: *Inventory of Army Military Real Property, the United States.*

To develop a long-term maintenance program, costs must be assumed for the time periods for which treatment is required. It is estimated that each acre will require on average 1 unit of reclamation every 6 years.

Fort Carson Land Areas

Fort Carson contains 137,391 acres of land, of which 56,170 acres are designated as available for track vehicle training.[11] The Fort Carson LUMP describes the various categories and types of land available at the site.[12] For the ROI study, the areas requiring treatment need to be delineated. The breakdown of the Fort Carson acreage (based on Tables A1 and A2 in the Appendix) is shown in Table 4. The pinyon-juniper and ponderosa-oak woodlands identified in the LUMP total 7880 acres. This entire acreage is assumed to require maintenance. The limestone and sandstone breaks that contain scattered trees total 21,500 acres. Portions of the break areas are untrafficable; the LUMP identified 13,820 acres as untrafficable. It is assumed that the LUMP had included the badlands, which contain 2100 acres, in its 13,820-acre total. This amount is subtracted, leaving an actual total of 11,720 acres of break area considered untrafficable. Thus 9780 acres of break area are trafficable and require treatment. In summary, 17,660 acres of land containing trees and scattered trees (i.e., woodlands and break areas) require maintenance. The prairie sites, or rangelands, requiring treatment are the difference between the 56,170 acres and the tree-containing areas, or 38,510 acres.

[11] *Draft Environmental Impact Statement (EIS), Training Land Acquisition for Fort Carson, Colorado.*

[12] *Land Use and Management Plan for Fort Carson, Colorado.*

Table 4

Fort Carson Acreage

Land Categories	Area	Woodlands	Breaks	Rangeland	Reference
Existing base area	137,391				*Inventory of Army Military Real Property*
Area available for training	56,170				*Draft EIS, 1980*
LUMP areas with trees					
Woodlands					
Pinyon-juniper		3,870			App. Tab. A3
Ponderosa-oak		4,010			App. Tab. A3
Total needing maintenance	7,880				
Break areas					
Limestone			12,820		App. Tab. A3
Sandstone			8,680		App. Tab. A3
Total	21,500				
LUMP untrafficable			13,820		App. Tab. A1
Badlands			-2,100		
Total untrafficable	-11,720				
Total needing maintenance	9,780				
Total woodlands and break areas needing maintenance	17,660				
Rangeland (treeless prairie) needing maintenance	38,510				
Areas for ROI	56,170	7,880	9,780	38,510	

Sources: *Inventory of Army Military Real Property, the United States; Draft EIS, Training Land Acquisition for Fort Carson, Colorado; Land Use and Management Plan for Fort Carson, Colorado.*

Determining the amount of time remaining at Fort Carson for vehicle training is a subjective process. The site has been intensely used since 1965, so it took about 20 years to reach its current state. The baseline assumption is that the site will be able to provide some level of military training for an additional 20 years at the pre-FEAP level of maintenance. Thus, the site is assumed to have a total acceptable training life of 40 years at pre-FEAP land maintenance levels. However, the impact of not having a maintenance program may not be acceptable (legally or otherwise).

Pinon Canyon Land Areas

PCMS contains 235,995 acres. Like Fort Carson, it is composed of prairie sites, limestone and sandstone breaks, and woodlands. The areas for different treatment activities were delineated from the information contained in the 1980 environmental impact statement (EIS) for acquisition of the site and are summarized in Table 5. (Tables A2 and A4 in the appendix contain the data upon which Table 5 is based.)[13]

The EIS examined 257,236 acres; the present size of PCMS is 235,995 acres, or 91.74 percent of the EIS study area. The EIS identified 42,625 acres as nonuse areas; for this study, 91.74 percent of the EIS area, or 39,105 acres, is considered nonuse areas. Thus, the total area available for training at PCMS is assumed to be 196,890 acres.

The loamy-plains/sandstone-breaks complex contains 38,521 acres; 40 percent of the area, or 15,408 acres, consists of sandstone breaks with scattered pinyon pine and juniper trees. The limestone-breaks/pinyon-juniper complex is 19,550 acres; 50 percent, or 9775 acres, consists of limestone breaks; 30 percent, or 5865 acres, is pinyon-juniper woodlands; and 20 percent of the site is inaccessible rock. The pinyon-juniper/rocklands complex comprises 37,364 acres; 60 percent of this area, or 22,408 acres, is identified as accessible woodlands. The pinyon-juniper woodlands area at the site is 28,273 acres. The limestone and sandstone breaks comprise 25,183 acres, and the rangeland is area that remains when the sum of the pinyon-juniper woodlands areas plus the break areas is subtracted from the total available site area, or 143,434 acres. Corrections to the EIS (91.74 percent differential) were not applied to these areas, and no corrections that would allow for the possibility of part of the break area being inaccessible were made.

Because land at PCMS is used rotationally, it is not used as much as is the land at Fort Carson. The percentage of the land used during training is the use ratio. The use ratio at PCMS was originally proposed to be one-third, but currently three-fifths of the available land is used during training, for a land use ratio of 60 percent.

For baseline conditions, the estimated life of PCMS is assumed to be 30 years. This is 10 years less than the estimated life of Fort Carson because PCMS is much more susceptible to wind erosion and is in a more delicate ecological setting than Fort Carson.

Residual Land Value

Even if the facilities were used so much they could no longer function as a military training area, the land would still have some residual value. If the land were not maintained at all, one could assume that most of the vegetation at both sites would be destroyed, many gullies would form, and the land would have less value than when it was purchased. An overall residual land value of $50/acre was assumed for the baseline conditions.

[13] *Draft EIS, Training Land Acquisition for Fort Carson, Colorado.*

Table 5

Pinon Canyon Acreage[a]

Land Categories	Total Area	Available for Training			Unavailable		Reference
		Woodlands	Breaks	Rangeland	Loamy Rocklands	Plains	
Area studied in 1980 environmental impact statement (EIS)	257,236						*Draft EIS*, Tab. 2-7
EIS-identified nonuse areas	42,625						*Draft EIS*, Tab. 2-7
Existing base area	235,995						*Inventory of Army Military Real Property*
Existing nonuse areas	-39,105						
Area available for training	196,890			196,890			
EIS Complexes				-53,456			
Loamy plains/ sandstone breaks	38,521						*Draft EIS*, Tab. 3-14
Sandstone breaks 40%			15,408				*Draft EIS*, App. C, p C-6
Loamy plains 60%						23,113	
Limestone breaks/ pinyon-juniper	19,550						*Draft EIS*, Table 3-14
Pinyon-juniper 30%		5,865					*Draft EIS*, App. C, p C-3[b]
Limestone breaks 50%			9,775				*Draft EIS*, App. C, p C-3[b]
Rocklands 20%					3,910		*Draft EIS*, App. C, p C-3[b]
Pinyon-juniper/ rocklands	37,346						*Draft EIS*, Table 3-14
Pinyon-juniper 60%		22,408					*Draft EIS*, App. C, p C-6
Rocklands 40%					14,938		
Total areas		28,273	25,183	143,434	18,848	23,113	
Total woodlands and break areas needing maintenance		53,456					
Rangeland (treeless prairie) needing maintenance		143,434					
Areas for ROI		196,890	28,273	25,183	143,434		

[a]Ratio of existing acreage to EIS-identified acreage = 91.74%.

[b]This Pinon Canyon complex is not described in App. C. The Huefano River description is used, based on the assumption that the descriptions given for the pinyon-juniper/rockland complexes are the same for both sites.

Sources: *Inventory of Army Military Real Property, the United States; Draft EIS, Training Land Acquisition for Fort Carson, Colorado.*

Acquisition Costs

The cost of acquiring an additional site when Fort Carson/PCMS is no longer usable cannot be easily quantified. However, the time involved in land acquisition, preparation of an EIS, and public hearings is long and expensive. For the baseline case, an EIS cost of $5 million is assumed, and all other costs are assumed to be $0.

Research Costs

The total project research cost for the FEAP was $565,000; approximately one-half of that amount was used for onsite rehabilitation.

4 RETURN-ON-INVESTMENT ANALYSIS

In this study, the ROI is the estimated savings to the government divided by the estimated cost of the long-term maintenance program. Two calculations were made for each of the various scenarios discussed in this chapter: the first is the ROI for the FEAP demonstration and research, and the second is the ROI for the long-term maintenance program.

Because of the complex nature of the costs and the lack of information on life cycle, all calculations were made in current dollars. No efforts were made to adjust for past or future inflation. This approach is conservative because costs were spread over time; for example, the government's costs of obtaining Fort Carson were spread across 45 years.

The land and facility costs listed in Table 3 have accumulated over 40 years. The replacement costs of these facilities cannot be estimated individually from the 1985 real property inventory. It is assumed that most of the facilities were built in the early 1940's and mid-1960's.

Figure 1 shows relative construction costs for the period 1915 to 1982. Between 1942 and 1982, construction costs increased by a factor of 9.5, and from 1965 to 1982 the increase was 3.2. Thus, the 1986 replacement cost for facilities built in 1942 through 1945 would be at least 9 to 10 times their original cost, and for facilities built in 1965 to 1968, it would be more than 3 times their original cost.[15] Therefore, a conservative estimate of the replacement cost of all the facilities should vary from no less than 3 times to over 5 times their original cost.

ROIs were developed for five different cost scenarios:

Case 1: all costs at actual government cost.

Case 2: land costs at $104 per acre, facilities at 2 times cost.

Case 3: land costs at $104 per acre, facilities at 3 times cost.

Case 4: land costs at $104 per acre, facilities at 4 times cost.

Case 5: land costs at $104 per acre, facilities at 5 times cost.

These five cases are examined for the baseline data as well as for the sensitivity of the ROIs to variations in the baseline assumptions.

Return-on-Investment Calculations

The ROI is calculated using the five scenarios plus the cost information just discussed. The baseline assumptions are shown on Table 6.

[15] *Comparative Building Cost* (Marshall and Swift Publication Company, Los Angeles, 1982).

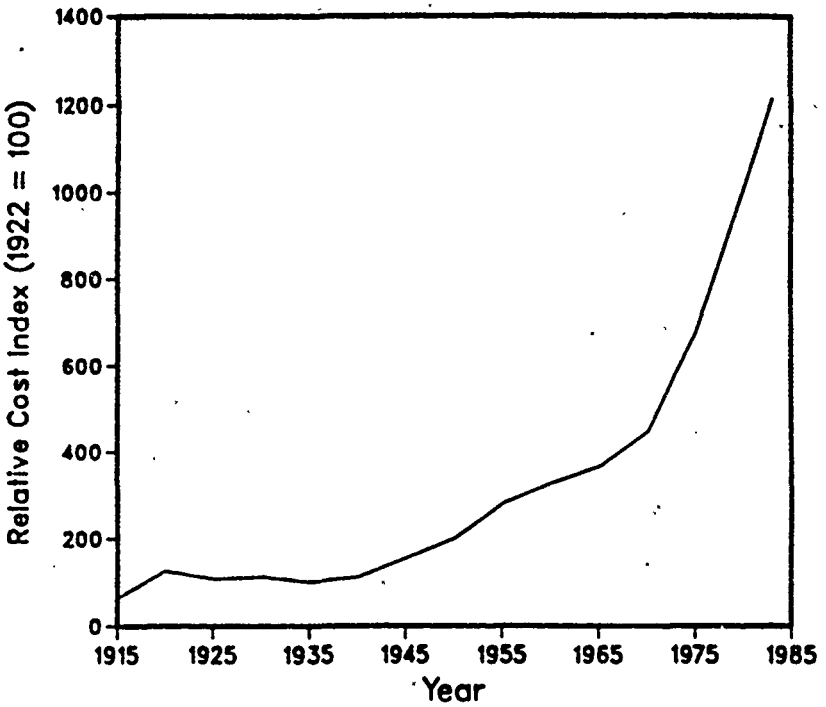

Figure 1. Building cost index (Source: Marshall and Swift, 1982).

Tables 7, 8, and 9 show the calculation for ROI. The five cases are identified across the top of Table 7, while the various cost categories are identified in the left-hand column. The Case 1 cost data for both sites are the same as those identified in Table 6. The Case 2 cost for land at Fort Carson is more than double the Case 1 land cost and holds constant for the remainder of the cases, but other cost elements increase. The high land value of $859/acre was not used since the Army would be more likely to relocate an installation in a remote area than to incur such a high cost for additional land. The building and other cost elements increase proportionally with the various multipliers from left to right. The procurement and acquisition costs are constant for the baseline scenario, as is the residual land value (shown in parentheses). The residual land value subtracted from the calculated cost leaves the total site cost. The total cost to the government for using the two sites ranges from more than $359 million for Case 1 to as high as $1,716 million for Case 5.

Maintenance costs are shown in Table 8. These costs are calculated by multiplying the size of each area by its maintenance cost per acre. For the Fort Carson site, this is a function of the maintenance cost for each type of area divided by the number of years between treatments, while for PCMS, this total is then multiplied by the use ratio, 60 percent, because all the available training land is not used. The total maintenance costs are obtained by multiplying the annual costs by the estimated remaining life for each site. The savings to the government are obtained by subtracting the maintenance costs from the site costs.

Table 10 provides the results of the calculations for the ROI. The implementation ROI is calculated by dividing the savings by the long-term maintenance costs. The research ROI is calculated by dividing the savings by the FEAP demonstration and research cost, which is $565,000.

Table 6

Baseline Assumptions

Assumptions	Baseline Value
Interval between rehabilitation (year)	6
Rehabilitation Cost ($/acre)	
Prairie	50
Woodland	175
Breaks	113
Fort Carson	
Total area (acres)	137,391
Available area (acres)	56,170
Usable prairie (acres)	38,510
Usable woodland (acres)	7,880
Usable limestone and sandstone breaks (acres)	9,780
Remaining life (years)	20
Pinon Canyon	
Total area (acres)	235,995
Available area (acres)	196,890
Usable prairie (acres)	143,434
Usable woodland (acres)	28,273
Usable limestone and sandstone breaks (acres)	25,183
Remaining life (years)	30
Use ratio (%)	60
Residual land value ($/acre)	50
Research cost ($)	565,000
EIS, hearing, and acquisition costs ($)	5,000,000

Table 7

Calculation of Replacement Costs for Lands and Facilities

Site Cost Categories	Size of site (acres)	Cost ($/acre)	Cost($) Case 1 Land = $46/acre Improv = actual cost	Case 2 Land = $104/acre Improv = 2 x cost	Case 3 Land = $104/acre Improv = 3 x cost	Case 4 Land = $104/acre Improv = 4 x cost	Case 5 Land = $104/acre Improv = 5 x cost
Fort Carson							
Land	137,391	46.00	6,319,986	14,343,620	14,343,620	14,343,620	14,343,620
Buildings			221,179,800	442,359,600	663,539,400	884,719,200	1,105,899,000
Other			116,049,514	232,099,028	348,148,542	464,198,056	580,247,570
Pinon Canyon							
Land	235,995	104.40	24,637,878	24,637,878	24,637,878	24,637,878	24,637,878
Buildings			0	0	0	0	0
Other			4,797,900	4,797,900	4,797,900	4,797,900	4,797,900
New site (EIS, public hearings, land acquisition)			5,000,000	5,000,000	5,000,000	5,000,000	5,000,000
Old sites (residual land value)	373,386	50.00	(18,669,300)	(18,669,300)	(18,669,300)	(18,669,300)	(18,669,300)
Total site cost			359,315,778	704,568,726	1,041,798,040	1,379,027,354	1,716,256,668

Table 8

Site Maintenance Cost Calculation

Site Maintenance Cost Categories	Size (acres)	Cost ($/acre/yr)	Cost ($/yr)	Remaining Life (yr)	Total Cost ($)
Fort Carson					
Rangelands	38,510	8	308,080		
Woodlands	7,880	29	228,520		
Break areas	9,780	19	185,820		
Subtotal			722,420	20	14,448,400
Pinon Canyon					
Rangelands	143,434	5	717,170		
Woodlands	28,273	18	508,914		
Break areas	25,183	11	277,013		
Subtotal			1,495,257	30	44,857,740
Total maintenance costs at both sites			2,229,381		59,306,140

Table 9

Cost Savings for Five Cases ($)

	Case 1	Case 2	Case 3	Case 4	Case 5
Site replacement cost	359,315,778	704,568,726	1,041,798,040	1,379,027,354	1,716,256,668
Less maintenance cost	-59,306,140	-59,306,140	-59,306,140	-59,306,140	-59,306,140
Savings	300,009,638	645,262,586	982,491,900	1,319,721,214	1,656,950,528

Table 10

Return-on-Investment for Rehabilitation Actions

	Case 1	Case 2	Case 3	Case 4	Case 5
ROI/Implementation	5.0	10.8	16.5	22.2	27.8
ROI/Research	531	1142	1739	2335	2932

Baseline Case

The ROIs for the baseline conditions are shown in Figures 2 and 3. Figure 2 shows the ROI for implementation of the FEAP maintenance program. The ROI varies from a low of 5.0 for facility replacement at government cost to 27.8 for Case 5. The ROI for the FEAP demonstration (Figure 3) varies from 531 for Case 1 to 2932 for Case 5. The linear increase from Case 1 to Case 5 indicates (1) more than doubling the land value at Fort Carson has little impact on the overall ROI, and (2) the costs of the facilities predominate in the cost of replacing a site.

Sensitivity Analysis

The sensitivity of the ROI to the various assumptions shown on Table 6 was studied to identify the most influential assumptions. Because the demonstration and implementation ROIs are proportional, only the variation of the implementation ROI was reviewed. The sensitivity analysis examined the impact of a single assumption on the ROI while all other assumptions were held at baseline values. The ROIs for an expected range of values for each assumption were determined, and the relative impacts of the different assumptions were observed.

Treatment Interval

This study assumes that a given area will require reclamation effort every 6 years. Figure 4 shows the impact of varying the reclamation interval from 2 to 10 years on the ROI for each of the five cases. The implementation ROI for the 2-year treatment interval varies from 1.0 to 8.6 for Case 1 to Case 5, respectively, while the 10-year-interval ROI varies from 8.9 to 46.9. The impact of this time variable is linear and significant. For example, Case 5: if the land must be treated every 2 years, the ROI is nearly 9. If the treatment interval is increased to 4 years, the treatment costs are one-half those incurred at the 2-year interval, and the ROI increases to approximately 18. As the treatment interval increases, the resultant treatment cost decreases and the ROI continues to increase.

As details on the long-term success of the rehabilitation efforts are documented through site monitoring, the optimum time interval for rehabilitation will be defined. At that point the ROI for long-term maintenance actions can also be refined. With continued research toward identification and development of more resilient rehabilitation measures, the ROI can also be increased.

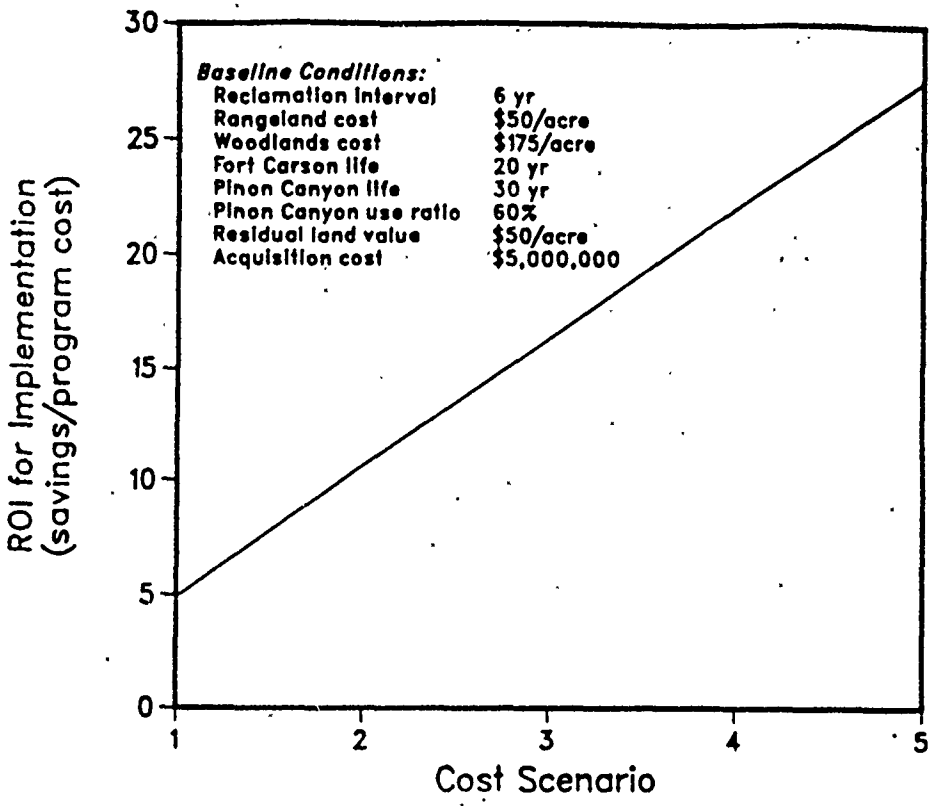

Figure 2. Baseline ROI for implementation.

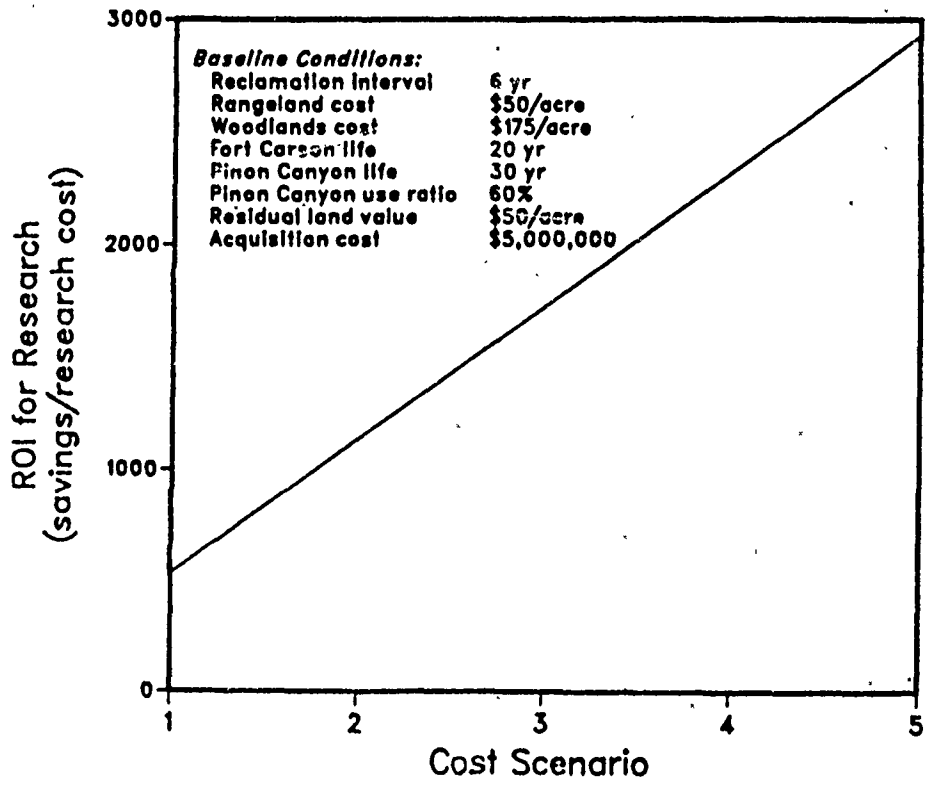

Figure 3. Baseline ROI for FEAP.

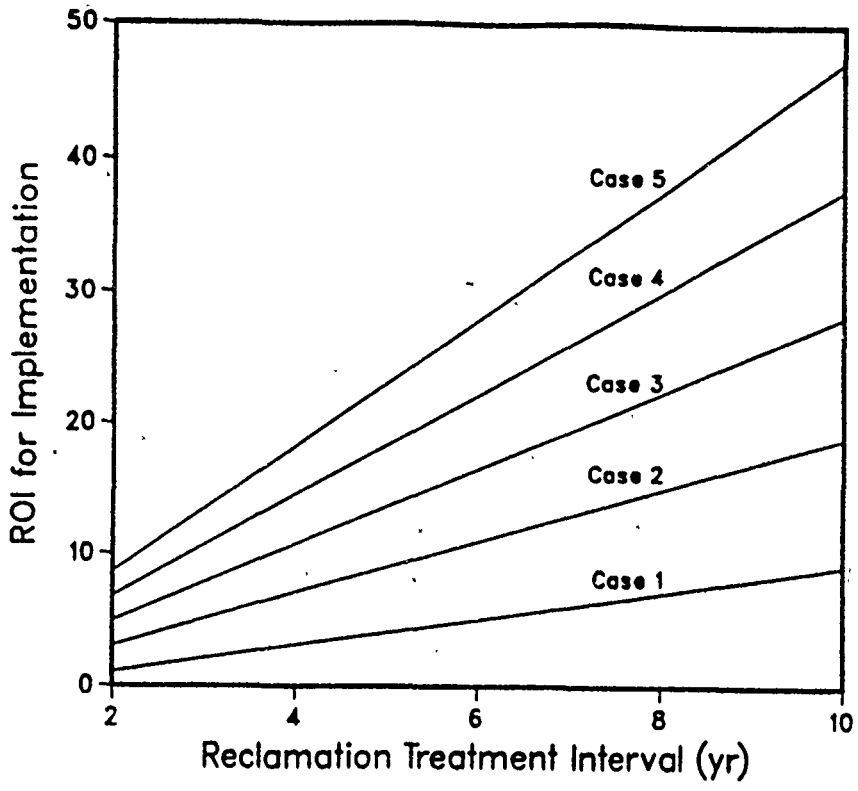

Figure 4. Sensitivity of ROI to reclamation treatment intervals.

Prairie Treatment Cost

A site's baseline prairie or rangeland treatment is assumed to cost an average of $50/acre. Figure 5 shows the differing ROIs for the five cases if the rangeland costs are varied from $0 to $100 per acre. Case 5 has an ROI of 58.2 for no rangeland treatment cost (which does not show up on the table) to a low of 18.0 for a $100-per-acre cost. Case 1 ROI varies from a high of 11.3 to a low of 2.9. Thus, as would be expected because so much rangeland is used, the cost of rangeland treatment significantly inversely affects the ROI. The cost of treating an individual acre of rangeland has a direct impact on the total treatment cost. Thus, a higher treatment cost per acre results in a higher total treatment cost. The ROI is greatest when the rangeland treatment cost is the least, and the ROI decreases as the rangeland treatment cost increases.

Note that the no-treatment action increases the return-on-investment at the expense of continued degradation of the land. That is, no treatment is at no cost or investment, so the ROI should be expected to be greater. In addition, the benefits of more realistic training were not defined within the scope of this study. If they could have been logically defined, increased benefits from treatment would substantially offset the incremental increases in treatment cost, thereby identifying an optimum level of expenditure for treatment. Illustrating this outcome remains a task for further economic study, when the long-term success of rehabilitation actions is determined and rehabilitation technologies are refined.

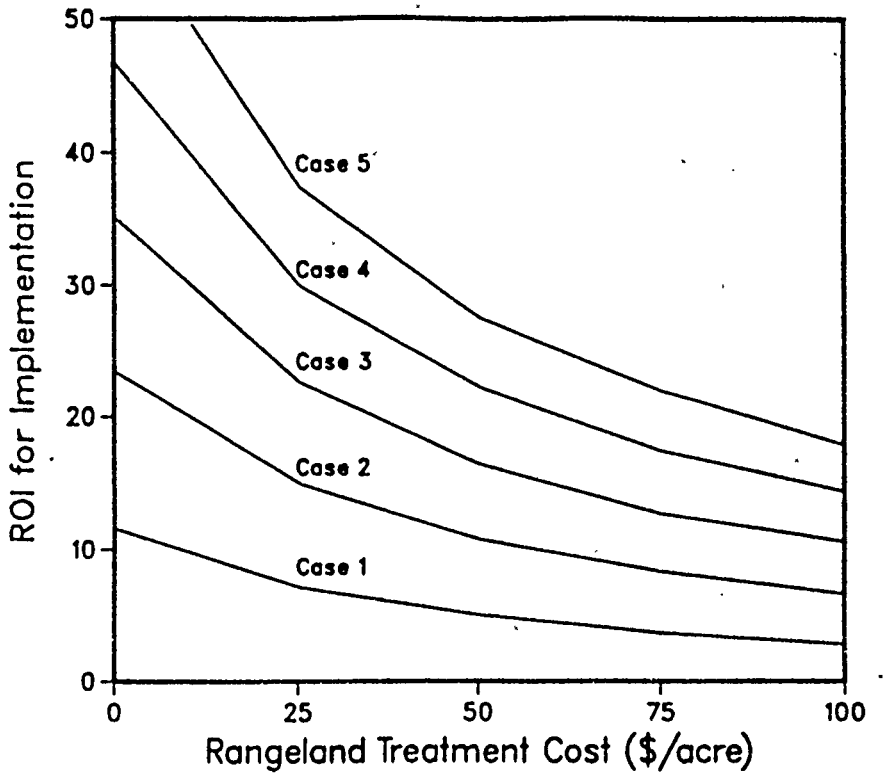

Figure 5. Sensitivity of ROI to rangeland treatment costs.

Woodlands Treatment Cost

The impact of treating the woodlands is shown in Figure 6. Woodlands treatment costs are assumed to vary from $75 to $275 per acre. The ROI is not as sensitive to variations in costs for treating woodlands as it is to variations in rangeland treatment costs. Case 1 varies from 7.3 for a $75-per-acre cost to 3.7 for a $275-per-acre cost. Likewise, Case 5 varies from 38.8 to 21.5 for the respective woodlands treatment costs. The woodlands treatment cost has the same type of impact on ROI as the rangeland treatment cost.

The lessened sensitivity of the cost for the woodland treatment compared to the prairie treatment is attributable to total number of acres treated. Both study sites have considerably more acreage in prairie than in woodlands. Therefore, increases in the cost of woodland treatment represent a much smaller investment than that required for prairie. The defined relationship of lower treatment cost to a higher ROI is anticipated to be the result of lack of data on the increased benefits of having a realistic training environment. This factor points to a need for definition of these benefits in further economic study of long-term maintenance actions.

Remaining Life of Fort Carson

The remaining useful life of the Fort Carson training areas was assumed to be 20 years in the baseline case. As can be seen in Figure 7, the ROI for Case 1 is 5.8 at a 10-year remaining life and decreases to 4.3 for a 30-year remaining life. The Case 5 ROI varies from 31.8 to 24.6 for the same years of life. The significance of this analysis is that a shorter site life results in a lower total maintenance cost. The amount of remaining life at Fort Carson has less influence than the rangeland or woodland cost on a given percentage change in the variable.

Remaining Life of Pinon Canyon

A 30-year remaining life was assumed to be the baseline condition for PCMS. The sensitivity study examined useful lives ranging from 20 to 40 years, and the results of the analysis are shown in Figure 8. For Case 1 at a 20-year remaining life, the ROI is 7.0; at 40 years, the implementation ROI decreases to 3.8. For Case 5 these numbers are 37.4 and 22.0, respectively. The lifespan of PCMS has a greater impact on the ROI than does the lifespan of Fort Carson because of the larger land areas at PCMS.

As was the case for the Fort Carson remaining life, the shorter the site lifespan, the less the total maintenance costs. This can also be interpreted as the less the maintenance, the shorter the lifespan. The qualifying factors here are the definition of lifespan and the degree to which lands become so degraded that training benefits are significantly decreased. These factors are avenues for further research.

Pinon Canyon Land Use Ratio

The PCMS land use ratio shows the amount of available land in use relative to the unused amount. A higher land use ratio means more land is being used and more treatment costs will be incurred. The 1986 land use ratio at PCMS was 3/5 or 60 percent. Its impact on the ROI is shown in Figure 9; a variation from 40 percent to 80 percent is examined. Case 1 at a 40 percent use ratio has an ROI of 7.0, while at an 80 percent use ratio, the ROI drops to 3.8. For Case 5 at 40 percent and 80 percent, these numbers are 37.4 and 22.0, respectively. Changes in the land use ratio have less impact on the ROI than do changes in the remaining useful life.

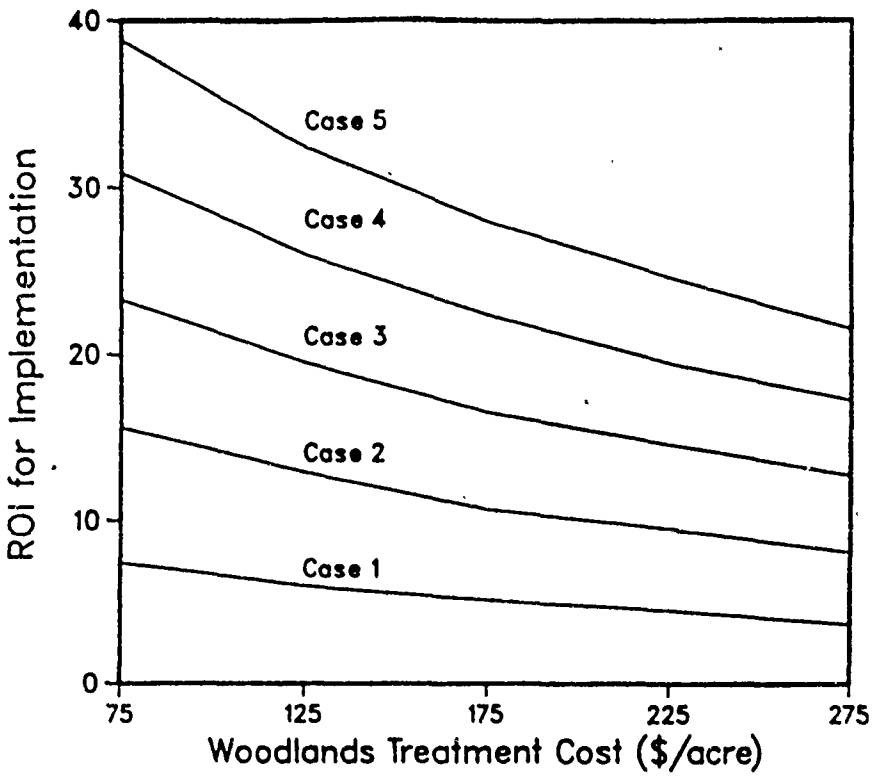

Figure 6. Sensitivity of ROI to woodlands treatment costs.

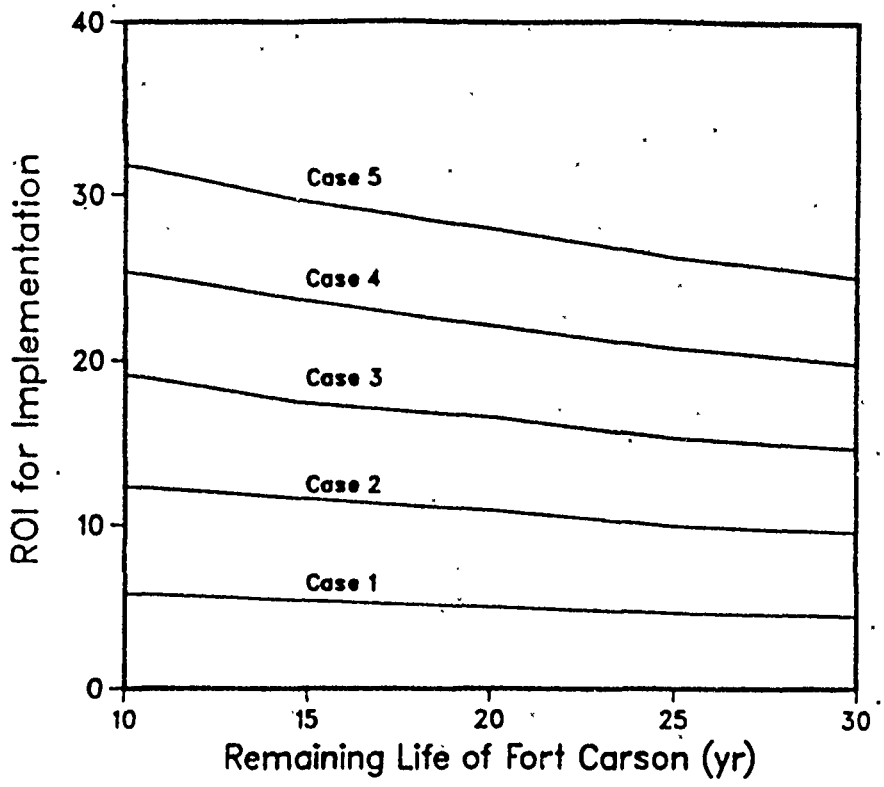

Figure 7. Sensitivity of ROI to remaining life of Fort Carson lands.

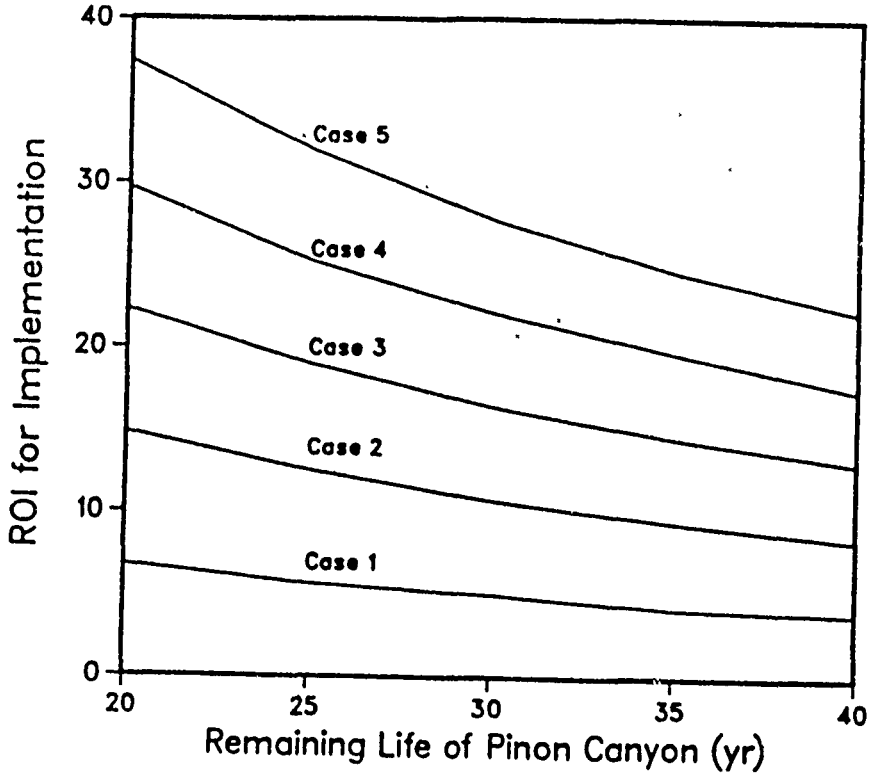

Figure 8. Sensitivity of ROI to remaining life of Pinon Canyon lands.

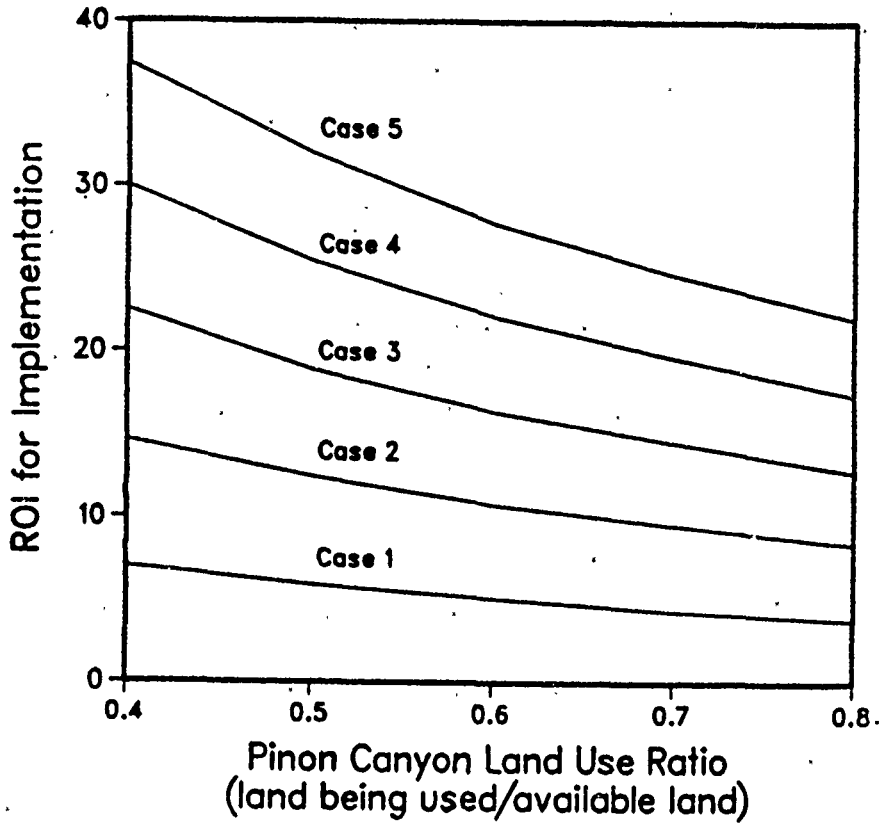

Figure 9. Sensitivity of ROI to percentage of training land use at Pinon Canyon.

Residual Land Values

Figure 10 shows that residual land values have little impact on overall ROI. The baseline case assumed a value of $50 per acre, and the sensitivity of the ROI to values ranging from $0 to $100 per acre was examined. Case 1 has an ROI of 5.3 for a residual value of $0 and an ROI of 4.7 for a residual value of $100 per acre. Case 5 has ROI values of 28.1 and 27.4 for the respective residual land values. The residual land value, which is the value at which the land can be sold, decreases the total cost of managing the site.

Acquisition Costs

The impact of acquisition costs, or the costs of an EIS, public hearings, litigation, etc., on the ROI is shown on Figure 11. A baseline case of $5 million was assumed, and a range from $0 to $100 million was examined. For Case 1, the initial ROI for no cost was 5.0, and for $100 million was 6.6. For Case 5, the ROIs were 27.7 and 29.4, respectively. The acquisition costs have less impact on ROI than do total treatment and facilities costs.

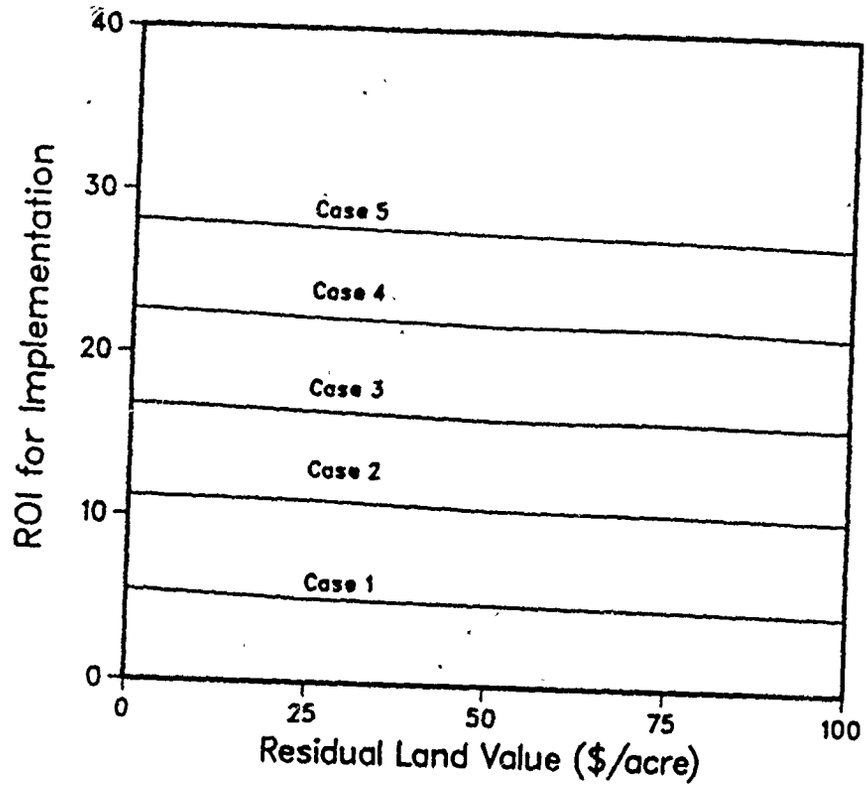

Figure 10. Sensitivity of ROI to residual land value.

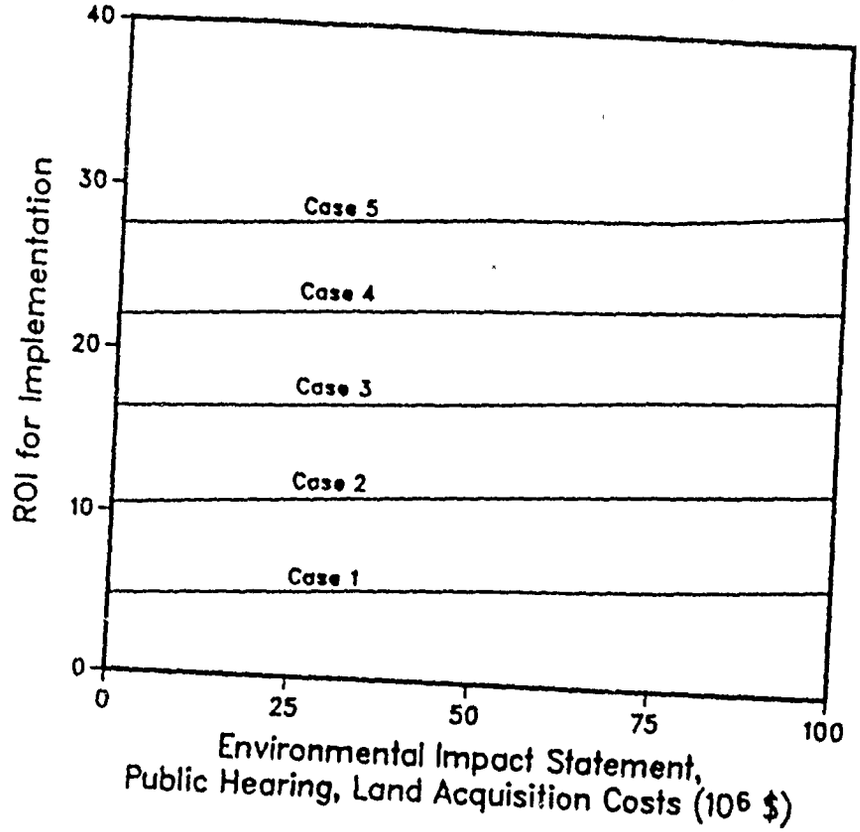

Figure 11. Sensitivity of ROI to acquisition costs.

5 CONCLUSIONS AND RECOMMENDATIONS

Results of this ROI study show that rehabilitation and maintenance are cost-effective for the Army. Estimates of the Government's savings at Fort Carson and PCMS vary from over $299 million to more than $1.65 billion based on implementation of a long-term management program that will provide the 4th Infantry Division with a training area for sustained use. The baseline ROI for implementation varies from 5.0 to 27.8 for the five cases considered; the ROI for the research costs associated with the FEAP project varies from 531 to over 2932 for the five cases. None of these cases considered the savings or value that could be realized from better-trained troops or the ecological benefits that would be derived from maintaining resources in accordance with Army regulations and guidance.

A study of the sensitivity of the ROI to variations in the different assumptions indicates the most critical factors are treatment interval (that is, the number of years that elapse between the application of land-maintenance treatment) and specific costs of the treatment. The amount of remaining life at each site had a significant impact on ROI, but not as great as the cost per treatment or the treatment interval. The critical element derived from the remaining-life sensitivity analysis is that no action or little attention to maintenance decreases useful life. Also, future acquisition costs, if extremely large, can affect ROI. However, these costs could not be quantified within the scope of this study. Finally, residual land value had virtually no impact on ROI.

The data shortfall of this initial ROI for establishing long-term rehabilitation actions is the lack of information on the benefits of realistic training. While the ROI and sensitivity analysis support a long-term program, additional research is require on the benefits of realistic training.

Based on the results of this ROI study, it is recommended that long-term land maintenance activities at Fort Carson and PCMS be supported. The Army should also consider expansion of long-term management programs to similar training sites. The wide variations in climatic and site conditions on U.S. installations will require site-specific determination of the management requirements. The value of successful development of an expanded program can be readily appreciated when one considers the restricted availability of land in the United States and at foreign installations in the future.

Benefits of continued rehabilitation research in support of these programs will only serve to enhance the ROI for these efforts. Through this research the best treatment techniques, optimum intervals of time between rehabilitation, and the most cost-effective seed mixtures can be developed. Thus, treatment costs can be reduced and training area life cycles expanded. This will also result in more realistic environments to provide better trained tactical military units.

METRIC CONVERSION TABLE

1 ft	=	0.305 m
1 acre	=	0.405 hectare
1 mi	=	1.61 km

APPENDIX:

BREAKDOWN OF FORT CARSON AND PINON CANYON LAND AREAS

TABLE A1

Fort Carson Acreage in July 1977

Areas	Environmental Total	Environmental Set-Aside	Off Limits	Unrestricted[a]	Usable to Untrafficable to Mechanized Vehicles	Mechanized Training Vehicles[b]
Nontraining						
Cantonment area	5,760	-	5,760	0	-	0
Small impact area	6,360	-	6,360	0	-	0
Butts AAF	570	-	570	0	-	0
Large impact area	15,680	-	15,680	0	-	0
East of large impact	5,030	-	5,030	0	-	0
Turkey Creek ranch	1,250	-	1,250	0	-	0
Training						
1A	2,940	-	240 (VHA)	2,700	-	2,700
2B	2,980	-	830 (Rod/Gun) 370 (ASP) 60 (Girl Scout)	1,720	-	1,720
2C	2,360	1,180 (Agony)	-	1,180	810[c]	1,180
3A	910	-	70 (SASP)	840	-	840
3B	4,030	1,470 (Agony)	-	2,560	1,000[c] (Agony)	2,560
3C	1,750	-	-	1,750	-	1,750
4A	4,450	590 (Agony)	-	3,860	-	3,860

TABLE A1 (Cont'd)

Areas	Environmental Total	Environmental Set-Aside	Off Limits	Unrestricted[a]	Usable to Untrafficable to Mechanized Vehicles	Mechanized Training Vehicles[b]
4B	3,720	-	-	3,720	-	3,720
4C	2,200	-	-	2,200	-	2,200
4D	5,490	-	-	5,490	-	5,490
5A	2,520	-	-	2,520	-	2,520
5B	2,460	-	250 (Red Devil)	2,210	-	2,210
5C	7,630	4,600 (Sullivan Park) 760 (Saw Tooth)	-	2,270	210 (Buck Hill)	2,060
5D	5,620	30 (Sullivan Park)	-	5,590	590 (Buck Hill)	5,000
6A	4,740	160 (Saw Tooth)	-	4,580	3,910 (Wild Mtn)	670
6B	5,840	1,040 (Red Creek) 230 (Stone City Flats)	-	4,570	-	4,570
6C	4,950	2,430 (Green Gulch) 390 (Stone City Flats)	-	2,130	1,340[c] (Green Gulch) 1,270 (Green Gulch)	860
6D	5.910	5.910 (Stone City Flats)	-	0	-	0

TABLE A1 (Cont'd)

Areas	Environmental Total	Set-Aside	Off Limits	Unrestricted[a]	Usable to Untrafficable to Mechanized Vehicles	Mechanized Training Vehicles[b]
7A	7,840	-	-	7,840	7,840 (Booth Mtn)	0
7B	1,600	-	-	1,600	-	1,600
8A	4,290	-	930 (Tank Table)	3,360	-	3,360
8B	6,590	1,270 (Young Hollow)	1,870 (Tank Table)	3,450	-	3,450
8C	3,120	-	-	3,120	-	3,120
9A	5,030	1,830 (Youngs Hollow)	-	3,200	-	3,200
Total	137,390	25,660	39,270	72,460	3,150[c] 13,820[d] 16,970[e]	58,640

[a]Unrestricted area = total area - (environmental set-aside area + off limits area).
[b]Usable area = unrestricted area - total untrafficable area excluding overlapping area.
[c]Overlapping area, not double counted.
[d]Total untrafficable excluding overlapping area.
[e]Total untrafficable including overlapping area.
Source: Land Use and Management Plan for Fort Carson, Colorado.

Table A2

Management Units at Pinon Canyon

Management Unit	Area in Acres[a] (Hectares)			Land Stability (%)		
	Total	Unusable Protected	Total Usable	Medium	Low	Very Low
A	50,299 (20,356)	2,218 (898)	48,081 (19,458)	63.2	36.8	0
B	48,102 (19,467)	0	48,102 (19,467)	66.2	32.8	1.0
C	39,415 (15,951)	3,250 (1,316)	36,165 (14,636)	86.1	11.4	2.5
D	45,761 (18,519)	0	45,711 (18,519)	83.5	0	16.5
E	38,786 (15,697)	2,284 (925)	36,502 (14,772)	57.1	36.2	6.7
F[b]						
Balanced use/protection and increased protection	0	0	0			
Increased use	44,969 (18,199)	0	44,969 (18,199)	89.5	2.8	7.7

Table A2 (Cont'd)

Management Unit	Area in Acres[a] (Hectares)			Land Stability (%)		
	Total	Unusable Protected	Total Usable	Medium	Low	Very Low
Transportation corridor	5,483 (2,219)	5,483 (2,219)	0	31.4	66.8	1.8
Wildlife protection area	29,390 (11,894)	29,390 (11,894)	0			
Total						
Balanced use/protection and increased protection	257,236 (104,103)	42,625 (17,250)	214,561 (86,853)			
Increased use	302,205 (122,302)	42,625 (17,250)	259,580 (105,052)			

Source: Draft Environmental Impact Statement, Training Land Acquisition for Fort Carson, Colorado.

[a]Measurement in acres is obtained by planimetry and includes only preferred boundary.
[b]Management Unit F was not included in preferred boundary but would be utilized in the Increased Use Scenario.

Table A3

Stability Ratings of Rangelands, Woodlands, and Badlands, on Fort Carson

Sites	Area (acres)	% of Total Land Area in Survey
With high ratings		
Clayey foothill	14,160	
Loamy foothill	11,100	
Sandy foothill	4,180	
Total	29,440	25
With medium ratings		
Loamy plains	23,220	
Sandstone breaks	8,680	
Gravel foothill	8,590	
Saline overflow	1,500	
Gravel breaks	1,400	
Sandy plains	1,070	
Overflow	890	
Sandy bottomland	340	
Total	45,690	39
With low ratings		
Limestone breaks	12,820	
Shallow foothill	9,560	
Ponderosa pine and oak woodlands	4,010	
Pinyon pine and juniper woodlands	3,870	
Alkaline plains	2,680	
Salt flat	390	
Total	33,330	29
With very low ratings		
Shaley foothill	4,050	
Badlands	2,100	
Shaley plains	2,070	
Total	8,220	7
Total land area in survey	116,680	100

Source: *Land Use and Management Plan for Fort Carson, Colorado.* Developed by Dames & Moore technical staff from the Fort Carson range site and condition map that had been prepared for the Fountain Valley Soil Conservation District by the USDA Soil Conservation Service.

Table A4

Soils and Vegetation at Pinon Canyon

Soil Range Unit and Range Site	Total Area in acres (ha)	% of Parcel	Soils and Physiography	% Perennial Plant Cover		Major Native Plants of Potential Plant Community	Total Annual Plant Yield in lb/acre (kg/ha)		Present Condition and Stability
				Potential	'79 Transects		Potential	'79 Estimate	
LP Loamy Plains	87,464 (35,397)	34.0	Deep and moderately deep medium-textured silty soils that are commonly calcareous to the surface, on broad gently sloping plains and mesas.	20	10.8 to 14.6	Blue grama dominates. Grows in association with galleta, ring muhly, red threeawn, squirrel-tail, cholla, prickly-pear, snakeweed, winterfat, and other drought-enduring plants.	200-1500 (220-1680)	1250 (1400)	Fair Medium
LS Loamy Plains/ Sandstone Breaks Complex	38,521 (15,589)	15.0	Moderately deep and shallow medium-textured stony soils that are noncalcareous with scattered areas of sandstone rock outcrops, on ridge tops and transitional areas between mesas and canyons.	30	10.8 to 14.6	For Sandstone Breaks: Blue grama, black grama, sideoats grama, needle-and-thread, little bluestem, mountain-mahogany, skunk-bush, scattered juniper and pinyon. For Loamy Plains: See LP for plants.	400-2400 (450-2690)	1400 (1570)	Fair Medium
SO Saline Overflow	17,101 (6,921)	6.6	Deep medium-textured alluvial soils that are commonly calcareous and moderately alkaline, in swales and depressions along drainage-ways. These areas receive water from adjacent areas in addition to rainfall.	50	3.1 to 15.8	Western wheatgrass dominates. It is associated with alkali sacaton, galleta, vine mesquite grass, and 4-wing saltbush.	400-2400 (780-2800)	1300 (1460)	Poor Medium

Table A4 (Cont'd)

Soil Range Unit and Range Site	Total Area in acres (ha)	% of Parcel	Soils and Physiography	% Perennial Plant Cover		Major Native Plants of Potential Plant Community	Total Annual Plant Yield in lb/acre (kg/ha)		Present Condition and Stability
				Potential	'79 Transects		Potential	'79 Estimate	
SaP Sandy Plains	4,070 (1,647)	1.6	Deep coarse-textured soils forming on long wind-deposited dunes crossing near the center of the parcel.	40	6.9 to 8.0	Blue grama forms the bulk of the cover; needle-and-thread, sideoats grama, sand dropseed, red threeawn, sand sagebrush, and yucca are important associated plants.	500-1600 (560-1790)	1400 (1570)	Fair Medium
MPD Loamy Plains/ Limestone Breaks Complex	17,535 (7,096)	6.8	Shallow and moderately deep medium-textured soils weathered from limestone that are calcareous to the surface. Scattered limestone fragments on shallow soils occupy 60%; moderately deep soils with silty surface occupy 40%. On small ridges and transitional areas.	25	5.6	For Limestone Breaks: Bigelow sage, cholla, 4-wing saltbush, snakeweed, winter fat, yucca, sideoats grama, New Mexico feathergrass, blue grama, galleta and little bluestem. For Loamy Plains: See LP for plants.	200-1200 (220-1344)	1300 (1460)	Fair Low
PR Limestone Breaks/ Pinyon-Juniper Complex	19,550	7.6	Shallow and medium-textured soils forming on limestone that are calcareous to the surface. Scatter limestone fragments on shallow soils occupy 50%; stony and rocky shallow soils occupy 30%; and rock outcrops of limestone and shale occupy 20%.	20		For Limestone Breaks: See MPD for plants. For Pinyon-Juniper: One-seed juniper and pinyon form a canopy of 10% or more with many species associated with Sandstone and Limestone Breaks.			Fair Low

Talbe A4 (Cont'd)

Soil Range Unit and Range Site	Total Area in acres (ha)	% of Parcel	Soils and Physiography	% Perennial Plant Cover		Major Native Plants of Potential Plant Community	Total Annual Plant Yield in lb/acre (kg/ha)		Present Condition and Stability
				Potential	'79 Transects		Potential	'79 Estimate	
AP Alkaline Plains	29,013 (11,742)	14.5	Moderately deep and deep fine-textured soils weathered from shales that are calcareous and moderately alkaline, on toeslopes below limestone ridges and along drainages.	25	8.9 to 9.7	Alkali sacaton, blue grama, galleta, western wheatgrass, 4-wing saltbush, cholla, Fremont goldenweed, and Franenia.	500-2000 (560-2240)	900 (1010)	Poor Low
SE Saline Overflow, eroded	6,465 (2,616)	2.5	Shallow fine-textured soils forming on calcareous and alkaline shale that is exposed by erosion at heads of drainage.	25		Alkali sacaton, blue grama, galleta, winterfat, 4-wing saltbush, cholla, snakeweed, and Fremont goldenweed form a sparse cover.	300-900 (340-1010)		Poor Very Low
TrG Pinyon-Juniper & Rockland	37,346 (15,114)	14.5	Moderately deep and shallow stony soils formed in sandstone colluvium that is noncalcareous, on canyon walls and sideslopes, occupying 60% of the unit. Cliffs and boulder rock outcroppings occupy 40%.			For Pinyon-Juniper: See PR for plants.			Fair Medium
SM Salt Meadow - This unit (about 0.1 percent of the parcel) is in the wildlife protection area. It is not included in training unit plans.									

Compiled from field studies of soils and vegetation, November 1979, and aerial photographs.

Source: Draft Environmental Impact Statement, Training Area Land Acquisition for Fort Carson, Colorado.

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